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ABSTRACT

For American Indian students, math anxiety and math avoidance are the most serious obstacles to general education and to the choice of scientific careers. Indian students interviewed generally exhibited fear and loathing of mathematics and a major lack of basic skills which were caused by a missing or negative impression of the mathematics capabilities of Native Americans, a generally negative image of mathematicians and scientists, dislike and fear of math forms without visible application to daily life and which require abstraction as a major tool, a perception of math courses and requirements as rigid, and a self-perception, often fostered by school couselors, of hopeless inadequacy in math skills. Because most of the students interviewed had attended public schools the implication is that public school math and science preparation is lacking for all, but especially for minority students. Changing math instruction can help remedy the situation. Some successful attempts at math instruction for Indian students employ a supportive atmosphere for math learning; individualized, non-competitive programs, tutorials, math anxiety clinics, exposure to Indian role models, courses with an applied focus directly related to a career or community need, and initial math skills education based on everyday mathematics. (SB)

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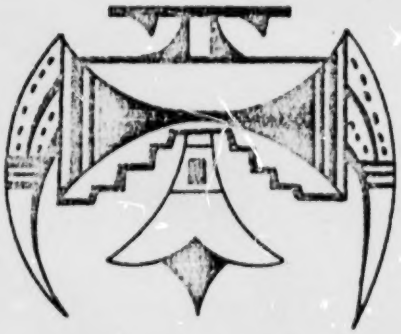

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MATH AVOIDANCE: A BARRIER TO AMERICAN INDIAN SCIENCE EDUCATION AND SCIENCE CAREERS

by

Rayna Green

Of all minority groups in the United States, Native Americans are the most poorly represented in the natural sciences, the health sciences and mathematics; yet Native peoples are the most needful of any minority group of status improvement in the areas of health, education and social welfare. Indian health needs are generally well-known, as are the grim facts of Indian underachievement in education. Even though the necessity for more Indian professionals in all fields and for economic development throughout the Native world tie together the major areas of concern, other needs beyond basic health care delivery and education exist in plenty. Most land-based Native Americans are in a serious struggle for the retention and development of the land they own, and in that struggle lies a potential for economic development which can change health care and education patterns for the good. Thus, Native engineers, geologists, hydrologists, resource planners and managers, conservationists, foresters, agronomists, aquaculture specialists, chemists, geneticists, animal husbandry specialists, and botanists—are all needed for resource development, management, and planning on Indian lands. Additionally, Indian teachers and programs in these fields are needed to raise the general educational level of Native people, as well as to provide meaningful career options for all Indians—rural, urban, land-based and not.

A number of agencies—Indian and non-Indian controlled programs operating at the national, state, and local levels—have begun to work in changing the pattern of Indian underrepresentation in the sciences and technical fields. As Director of the AAAS Project on Native Americans in Science, I have prepared reports which attempt to offer perspective through analysis of the problem ("The Barriers Obstructing the Entry of Native Americans into the Natural Sciences," MS 1976) and through a plan for remedial action ("Recommendations for the Improvement of Science and Mathematics Education for Native Americans," *BIA Education Research Bulletin*, Vol. 5, #1, January 1977). This article addresses one of the barriers to a scientific education and career and discusses various strategies for removing this particular obstacle from the path of American Indian students. The full research report and the set of recommendations are available from the Project on Native Americans in Science at AAAS. The report, the recommendations and this article are based on a year of formal and informal interview and discussion with Indian students, educators, counselors, teachers, scientific, technical and health professionals, and program developers as well as with non-Indian science educators, advisors, funding agency professional association and staff.

In general, I have found that many different kinds of barriers to the entry of Indian students into the sciences exist: some are cultural and attitudinal, some institutional, others technical and skill-related. In general, Indian students in the study appear to have numerous barriers. Some barriers are obvious, while others are more subtly harmful: poor or no counseling; bad, unskilled teachers; a negative image of science and scientists; no role models; lack of money for college; fear of failure; poor preparation in basic skills; lack of community priority for collegiate education; parental, family or marital problems, culture conflicts; and poor study habits; all contributed to retard educational progress. Those blocks to their general education are even bigger when it comes to choosing "deviant" careers in science and math. Of all the skill and attitudinally-related obstacles to success in both their general education and to a potential choice of a career in the sciences and technical fields, however, mathematics anxiety and math avoidance seem to be the most pervasive and serious. Poor preparation in math, combined with a widespread and debilitating form of math anxiety—as Shiela Tobias has termed it in her reports of research on women at Wesleyan—appear to be a singularly important factor in both collegiate success and career choice.

Almost all of the Indian students in the "Barriers" study—even those who had chosen the sciences and technical fields where exposure to, need for, and use of math is much greater than in the humanities—expressed a great anxiety at being able to do and understand math. Most expressed a distaste for math even when they were relatively competent in the skills required of them. And even if their anxieties about ability to do math had been allayed by recent successes, the power of their real or imagined failures in the past caused nothing but trouble for them in the present. Most non-science students avoided math whenever they could, and they and the science students struggled painfully with it when avoidance was not possible. The problem that math represents for them can be clearly understood when one views the statistics of Indian career choices—fewer than five Ph.D.'s in mathematics in the country; fewer than ten Ph.D.'s in the physical sciences, the most math-related of the natural sciences; less than fifteen Ph.D.'s in the "hard" or quantification-oriented social sciences and fewer than five in economics, less than two hundred engineers and fewer than twenty in the computer fields. (Most are in the low-level two-year programs.) In the small sample of eighty-five students interviewed for the "Barriers" project, I spoke with only two math majors, several students who had been tutors, and several science students who had math minors. But I met a large number of science students who had dropped math as a major, and most of those had then entered the biological rather than physical sciences as fields of study.

It was not, however, the lack of math majors that seemed the most significant factor in the study. It was the widespread, operative fear

and loathing of math; the widespread fear of failure in math; and the widespread lack of basic math skills needed to do other academic tasks (operate a slide rule, understand calculator operations or computer programs, deal with statistics, measure and calculate chemical substances for lab work) that stood out as major and ominous. Many students simply lacked the basic skills, and they sought out or were assigned tutors to help remedy their skill-related problems. For some of the students, who really perceived their problems as specifically skill related ("I never understood percentages"), tutoring at that problem level worked. They learned to calculate percentage and use a slide rule. For most, however, the skill-related problem was the tip of the iceberg. A large number of students reported dropping courses before they experienced failure or dropping at the first moment they felt a skill inadequacy appearing. ("I was afraid I couldn't hack it"; "I was supposed to take college algebra twice, but I was afraid it'd be too hard"; "I would've had more math but I was afraid of flunking.") A similarly large number reported delaying signing up for a course—usually college algebra or calculus—until they were forced into it by requirements to graduate. Few ever expected to do well in math and nearly all believed it was the hardest subject they ever had to take. They all seemed to sense that they should have taken more math in high school. ("It's essential in college"; "I'm not as good as I could be"; "I have a math and science deficiency now and it's hard to make up"; "I have to catch up in math; it's just not my subject"; "I always tried to get out of math and science courses in school. I went to Indian school and all the other Indians tried to get out of it. But now I wish I'd taken more." "All the counselor kept telling me was to take more math, and now I wish I had.") So, they know that schools think it's important; they know they'll need it, especially those in scientific or technical fields, but fear keeps them out and causes them to avoid the experience of failure. The curious thing is that very few of them had ever actually failed. Even those (surprisingly, more women than men in the sample) who had taken four years of science and math in high school, avoided and feared it.

Why do they avoid it? What has been their experience of math? I asked students what their experience of the history of the development of mathematics had been and they replied that they'd learned about Egyptians' and Europeans' contributions. None had heard of Mayan mathematical systems or the numbering systems of the Sioux, Iroquois, or Algonquian peoples. They had either no knowledge or a negative impression of the mathematical and scientific capabilities of Native peoples.

I asked them what their math teachers had been like in grade school and in high school. Very few replied that math teachers had been bad teachers per se. Several mentioned that teachers were not really math teachers, but coaches, for example, and that was perceived as bad. The predominant feeling was that math and science teachers had the reputations of being hard, tough, unyielding, and difficult. ("The

teachers and the course had a bad reputation"; "Science and math teachers had a reputation of being hard.")

Several said that their math teachers had been good. ("There's a good math teacher here"; "The math teachers there really lived and breathed math"), but that they just didn't like the subject. ("I like my math teacher here, particularly math methods, but not math.") Specifically and fairly uniformly, the students didn't like the more abstract courses. Algebra and calculus are the most feared, most avoided, most disliked courses of all, while geometry and trigonometry appear to have a more affirmative reputation. ("I tried harder in algebra, but I just slid through. I just don't like it. But I like trig and geometry." "I like courses related to daily life, and I can't see algebra as related to anything"; "I have a general problem in abstract reasoning.") Whether the problem is related to abilities to do abstract reasoning with a Western linear mathematical system, as some scholars have suggested, to poor preparation in abstract reasoning, or to an irrational fear of abstract reasoning, I cannot say. But the students, in general, do not like and are afraid of those forms of mathematics which do not have a highly visible application to daily/technically related problems and which require abstraction as a major tool.

Another problem—beyond hard teachers and fear of abstraction—seems to lie in the compulsory and rigidified nature of mathematics learning and school course requirements as the students perceive them. Sometimes, because a particular course was to be taken at a certain period and sequence in the schooling (calculus after college algebra in second semester, freshman year), students were placed in courses they did not feel ready for. ("The counselor insisted I go into calculus, but I knew I couldn't do it and dropped the course before I flunked.") Little account of the student's real capabilities, as determined through testing and personal interview, assessed where the student was. And in another sort of instance, students were told—in so many words—that they ought to be afraid of mathematics; that they would indeed fail. ("I got counseled out of mathematics into shop because the counselor said I would flunk"; "I was advised against taking algebra courses because I'd gone to a small school.") In yet a third situation, the student was stopped from going on to a higher level science course because of an arbitrary or rigid course sequence or decision by an administrator, and thus turned off permanently to the subject he/she wanted to take. A very superior Senior Pharmacy student told of wanting to take a senior chemistry course and being told by the principal, a math teacher, that she could not take the chemistry without taking calculus at the same time. She still harbors resentment against the principal and, not at all surprisingly, against math. In my own case, I was told that mathematics deficiencies meant that I should drop out of pre-med. As with the other students, no remedy but dropping or avoidance was suggested.

So, many students drop math courses they need for future work, courses they need for basic skills, courses that would lead them to a greater level of achievement, and courses that could prepare them for certain careers before they fail. They think twice and sometimes quite finally about certain careers in scientific and technical fields because of a perception of themselves as hopelessly incompetent in the mathematical skills needed for the career. Sometimes, as in my case and the case of the Occupational Therapy major who stayed out of the field for several years because she'd been told she'd need a lot of math, their sense of the mathematics competence they need is erroneous. Some students' fear and loathing of math are carried into their elementary education majors and on into the schools where they transmit that feeling to students. And if they teach Indian students, another generation continues the pattern. One suspects that the pervasive fear and dislike of mathematics is not uncommon among schoolteachers in general. How much more problematic is it that such an atittude is passed on to students who have neither role models nor models for success in those areas of learning?

Add to their bad experiences with math learning a generalized negative image of science, scientists, math and mathematicians, and the reasons for their math avoidance behavior becomes clearer. To these students, mathematicians are "calculating, obsessive, sloppy, out of touch interpersonally, isolated, remote, rough teachers, and hard workers." Even those students who had had math teachers they both liked and thought were good teachers felt this way in the abstract about mathematicians. Who would want to be described by most of those terms, and who would want to succeed in a field if indeed it meant that one would become—in the abstract—like those who are the professionals in the field? Mathematics seems to have a mystique attached to it. It is hard, the students feel; in fact, the hardest subject for everyone. They believe math teachers are mean and hard. Only the very smartest people succeed in mathematics, but they are cold, rational, distant, beings lacking in sociability and personal warmth. Math has little pragmatic use, but even when it has clear practical uses, the way to learn those forms of math are blocked and obscured by unpractical, abstract, useless forms. One cannot do anything of scientific importance without mathematics; indeed, without a command of math, one is somehow a lesser light no matter what their other competencies. Math majors are the "brains" in schools. And most minority and female students, no matter what their real competencies and potential, have difficulty envisioning themselves as "brains."

For traditional Indian students, raised in a community-oriented world where the maintenance of harmony and equilibrium means never being singled out for reward or status, the traditional image of the loner mathematician and the traditional question-answer-test-competition based classroom creates discomfort and encourages failure. When they have no Indian people as math teachers, see little

application of mathematics to their careers, the learning of mathematics is seen as a form of punishment rather than as either a career/life tool or an orderly, logical system which can bring pleasure in and of itself.

Math, physics and computer-science courses which are both devoid of warm, personal, friendly relationships at the base of problem-solving and which bear no resemblance to the students' real career needs nor to the needs of Indian people as they perceive them cannot succeed. Moreover, when the ultimate goal of a math and physics major is translated into production of graduate level research scientists or teachers, as the Indian students I interviewed perceived it, the limitations of the fields combine with the negative perception of the learning experience to drive students away from those fields altogether. "He didn't value the field, even though he was as good as any student I'd seen," one professor said of a drop-out science major, and the same appears to be true of both drop-out math majors and math-anxious science and non-science students.

But is the picture all bad vis a vis math? It is not, and some attempts to address the problem have succeeded. While I have not seen the adoption of full-scale math anxiety clinics, as in the Wesleyan and Mills College models for women, several programs have developed and are working. At Bacone College in Muskogee, Oklahoma, an NSF-Minority Institutions Science Improvement Program-funded program for the development of individualized mathematics and science curricula has resulted in a considerable change in attitude on the part of students and teachers. The head of the program told me that he had completely altered his opinions about the necessity of a conventional mathematics instruction. And the students, using the programs with tutors, many of whom are Indian, are changing their minds about math and their own capabilities. "I can't take tests," one student said, "but here at Bacone, they have individualized programs and I can work through the problems myself. Also, the math teachers here don't have lower standards because we're Indian." ("I have trouble with Algebra, but now I see it as a challenge. I've read about famous people who've failed many times before they succeeded. My tutor believes in me and I'm learning to believe I can do it. My math deficiency has held me back, but there are good math tutors here, and the individualized programs make it easy to work without being embarrassed.") The one enthusiastic math major I met was a tutor in this program, and he had already worked his own way through calculus and was ready for differential equations when he transferred to the University of Oklahoma in the fall. At other schools like the University of Oklahoma, the BIA Indian Students Services Office and the Indian Engineering Program had provided tutors for the students. And some students had responded again to the individualized, self-reinforcing tutorial even though no special program had been developed for math instruction. "I dropped school altogether because of math and physics," one engineering student told

me, "but I came back and made it with a tutor." For some, the difference was made by finding a teacher they liked and trusted. ("I changed math teachers to one I liked, and then it was okay. My math methods teacher has given me some confidence that I could do algebra. She doesn't embarrass you if you don't know how to do something.") And for others, at the Southwestern Oklahoma State University Minority Biomedical Science Program, for example, the supportive framework of several students in the same program working together and sharing similar anxieties and successes, made the difference between success and failure. "You know, when you work alone, you think it's just you with the problem, but here, I realized I wasn't the only dummy. I could even help someone else sometimes."

Thus, courses, programs, remedial activities—all could be turned around and changed to offer the Indian student a supportive atmosphere for mathematics learning, whatever the ultimate goal of the learning. Individualized, non-competitive, program or relationship-based instruction, tutorials, math anxiety clinics and individual therapeutive sessions for more deeply seated and debilitating problems, exposure to Indian role models in math and math-related fields as well as to Indian peer tutors, programs and courses with an applied focus directly related to a career or community need, initial mathematics skills education based on the math of everyday life, culturally-based mathematics education, demonstrations of processes rather than the formulaic applications of rules to obtain product-answers—all could make the difference in the mathematics experience and competency of Indian students. I cannot help but think that the benefit would be to the scientific, technical and mathematical fields as well as to the general education of Native peoples.

The curious thing is that most of the students in my sample came from public school, and indeed, over 60% of American Indians now attend public schools in urban centers and semi-rural areas, just like the students in the "Barriers" study sample. I have concluded that, in general, the public schools' preparation of most students in science and math is sadly wanting; that it is most doubly wanting when it comes to answering the needs of minority students; that little attempt is made to answer to specific minority characteristics or needs when attempts are made to remedy the problem; and that the kinds of Indian students who do not share in the fairly respectable public education afforded many of the students in my sample may be in worse shape than anyone else. Thus, much of what is wrong with the pre- and post-secondary mathematics education received by these students is wrong with public education in general. Much of what can be said of these students can be said of semi-rural, small town, public school educated, lower middle to lower class students everywhere, and recent test scores tell us that the same can be said of their middle to upper middle class peer groups in the cities as well. But much of what

is right about these students—their abilities, perseverance, toughness, essential mental health, aspirations for themselves and their communities is right about any group of students who've struggled to do what they've chosen to do. And there is much that is right about the kinds of educators who have attempted to remove some of the obstacles in their path to do what they've chosen to do. Mathematics competency is at the heart of a major obstacle both to career choice and to achievement of skills now lacked in Indian communities. And change is needed to insure general mathematics competency for American Indians, both capable and needful of the benefits that a positive change would bring.

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